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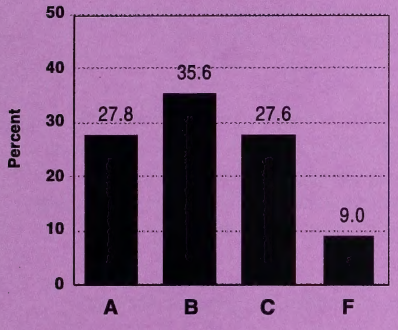
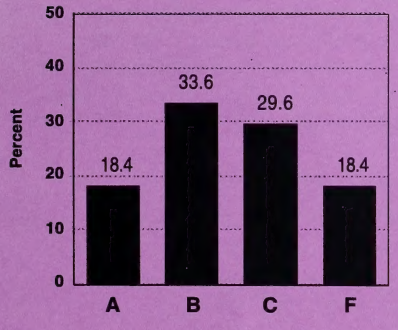
Chemistry 30

Diploma Examination Results
Examiners' Report for June 1995

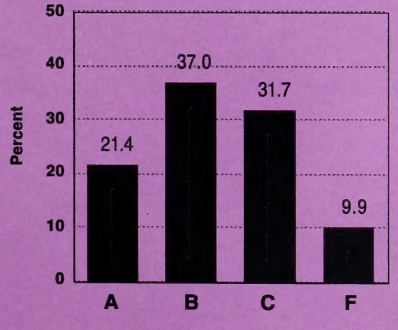
School-Awarded Mark



Diploma Examination Mark



Final Course Mark



The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the June 1995 administration of the Chemistry 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. An annual provincial report containing a detailed analysis of the combined January, June, and August results is published each year.

Description of the Examination

The Chemistry 30 Diploma Examination consists of 44 multiple-choice questions worth 55%, 12 numerical-response questions worth 15%, and 2 written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 8 106 students in Alberta who wrote the June 1995 examination. This represents an increase of 405 compared with June 1994 and a decrease of 1 060 students compared with June 1993.

- 90.1% of the 8 106 students achieved the acceptable standard (a final course mark of 50% or higher).
- 21.4% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Overall, student achievement in Chemistry 30 was acceptable, particularly in knowledge of core concepts. However, students had difficulty with the concept of equilibrium, and in organizing and communicating their chemistry knowledge.

Approximately 52.2% of the students who wrote this examination were female, which is similar to the percentage of females in the population at this age group. The acceptable standard on the examination was achieved by approximately 82.3% of this female population, compared with 80.9% of the male population. Approximately 17.4% of the female population achieved the standard of excellence on the examination, compared with 19.5% of the male population.

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Provincial Averages

- The average school-awarded mark was 69.0%.
- The average diploma examination mark was 64.4%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 67.0%.

Approximately 10.4% of the students who wrote the examination in June 1995 and received a school-awarded mark had written at least one other Chemistry 30 Diploma Examination during the January 1994 to January 1995 period. This sub-population (843) did not do as well (61.7%) as the population (7 263) who first wrote a Chemistry 30 examination (64.7%) in June 1995. However, the group of students who rewrote the chemistry examination increased their score, on average, from 51.1% to 61.7%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable level will obtain a mark of 50%, and students capable of achieving the level of excellence will obtain a mark of 80%. Future examinations will continue to require students to demonstrate clarity in their thinking, and an understanding of concepts by applying their knowledge to new and novel situations. Students will also continue to be required to present their answers in a clear, concise, organized fashion and to respect the conventions of the mode of communication selected. Those who achieved these expectations were successful in this examination.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the difficulty indicates the percentage of students answering the question correctly. For written-response questions, the difficulty is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge:

- GLE 1 Quantitatively Predicting Outcomes
- GLE 2 Qualitatively Analyzing Systems
- GLE 3 Relationships in Energy Transfer
- GLE 4 Relationships in Electron Transfer
- GLE 5 Relationships in Equilibrium Systems
- GLE 6 Relationships in Proton Transfer

Skills:

- SPSC Scientific Process Skills and Communication Skills.

Science, Technology, Society:

- STS Connections Among Science, Technology, & Society.

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPSC	STS
MC 1	D	0.612	√		√				√	√
MC 2	B	0.779		√	√				√	√
MC 3	D	0.695		√	√				√	√
MC 4	C	0.692	√	√	√				√	√
MC 5	D	0.549		√	√				√	√
MC 6	A	0.969		√	√				√	√
MC 7	A	0.644		√	√					√
MC 8	D	0.794		√	√					
NR 1	1123	0.312		√	√	√			√	√
MC 9	A	0.818		√		√			√	√
MC 10	B	0.704		√		√		√		
MC 11	A	0.633		√	√	√				
MC 12	B	0.752	√			√				
MC 13	C	0.439	√			√				√
MC 14	C	0.895	√			√				

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPSC	STS
MC 15	D	0.818	√			√			√	√
MC 16	C	0.810		√		√			√	
MC 17	D	0.411		√		√		√	√	
NR 2	1234*	0.807		√		√			√	
NR 3	7658	0.653		√		√			√	
NR 4	27.8	0.181	√			√			√	
NR 5	4231	0.888		√		√			√	
MC 18	C	0.794		√		√			√	
MC 19	B	0.555	√	√		√			√	
NR 6	2.78	0.592	√	√		√			√	
MC 20	D	0.641	√	√		√				
NR 7	1.18	0.557	√			√			√	
MC 21	A	0.874		√		√			√	√
MC 22	C	0.727	√	√		√			√	√
MC 23	D	0.461	√			√			√	√
MC 24	C	0.627		√		√			√	√
MC 25	B	0.688	√	√			√	√	√	√
MC 26	D	0.717		√				√		
MC 27	C	0.516		√				√		
MC 28	A	0.911		√				√	√	√
MC 29	D	0.610		√			√	√		
MC 30	B	0.289	√	√				√	√	
NR 8	66.7	0.122	√					√	√	
MC 31	A	0.773	√	√				√	√	
MC 32	A	0.609		√			√			√
MC 33	D	0.899		√			√	√		
MC 34	D	0.819		√				√	√	√
NR 9	3124	0.896		√				√	√	
MC 35	C	0.760		√			√	√	√	√
MC 36	A	0.584	√	√			√	√		√
MC 37	C	0.491	√				√	√		
MC 38	C	0.892	√					√	√	√
NR 10	4.62	0.290	√				√	√		
NR 11	7.54	0.160	√				√	√	√	√
MC 39	B	0.856		√	√				√	√
NR 12	7.84	0.714	√		√				√	√
MC 40	B	0.665	√		√				√	√
MC 41	D	0.622		√	√	√			√	√
MC 42	A	0.610		√			√	√	√	√
MC 43	B	0.765		√		√			√	√
MC 44	A	0.807	√			√			√	√
WR 1	—	0.684	√	√			√	√	√	√
WR 2	—	0.545	√	√	√				√	√

* in any order

Subtest

When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

- Multiple choice and numerical response: 36.7 out of 56
- Written Response: 14.6 out of 24

GLE 1	Quantitatively Predicting Outcomes	29.0	out of	49
GLE 2	Qualitatively Analyzing Systems	41.9	out of	63
GLE 3	Relationships in Energy Transfer	16.1	out of	26
GLE 4	Relationships in Electron Transfer	17.1	out of	26
GLE 5	Relationships in Equilibrium Systems	13.8	out of	22
GLE 6	Relationships in Proton Transfer	20.2	out of	32
Skills		28.4	out of	44
STS		35.1	out of	54

16. Laboratory wastes must be carefully collected and stored for proper disposal. Which of the following materials would be suitable as a container in which to store an aqueous solution of nickel(II) nitrate?

A. Aluminum
B. Chromium
***C.** Tin
D. Zinc

Use the following information to answer the next question.

Experimental Design: Metals and solutions of their ions are tested for evidence of reaction.

Observations:

	$Np_{(s)}$	$Mn_{(s)}$	$Os_{(s)}$	$Ac_{(s)}$
$Np^{3+}_{(aq)}$	–	×	×	√
$Mn^{2+}_{(aq)}$	√	–	×	√
$Os^{2+}_{(aq)}$	√	√	–	√
$Ac^{2+}_{(aq)}$	×	×	×	–

√ denotes a reaction
× denotes no reaction
– denotes not tested

Key:

1	$Np_{(s)}$	**5**	$Np^{3+}_{(aq)}$
2	$Mn_{(s)}$	**6**	$Mn^{2+}_{(aq)}$
3	$Os_{(s)}$	**7**	$Os^{2+}_{(aq)}$
4	$Ac_{(s)}$	**8**	$Ac^{2+}_{(aq}$

Numerical Response

2. With reference to the key, list the four reducing agents in any order. _____.
(Record your answer on the answer sheet.)

Answer: **1234**

Numerical Response

10. The pH of a sample of 0.020 mol/L $HOCl_{(aq)}$ used in treating poor water is _____.
(Record your answer to three digits on the answer sheet.)

Answer: **4.62**

Multiple-Choice and Numerical-Response Questions

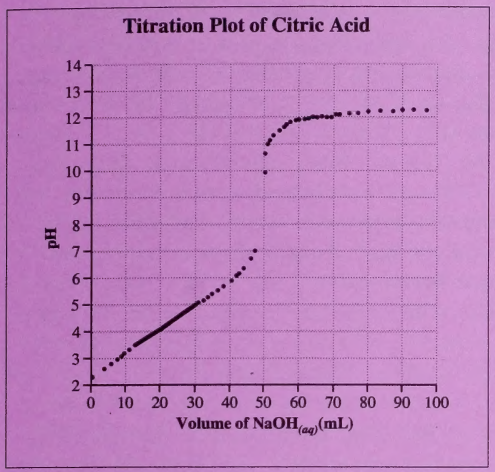
The following questions were selected for discussion because they exemplify what is required to meet, minimially, the acceptable level and the level of excellence.

Students just attaining the acceptable standard were capable of answering questions such as multiple-choice questions 2, 8, 9, 16, 18, 31, 34, and 44, and numerical-response question 2. For example, in **multiple-choice question 16** most students (81.0%) were able to identify nickel(II) ion as an oxidizing agent, and hence that it should be stored in a container made of a substance with a reduction potential greater than –0.26 V. The majority of students (84.4%) who attained the acceptable standard, and 98.2% of those who achieved the standard of excellence had success on this question, while 51.8% of those who did not attain the acceptable standard were successful. The results for this question suggest that students who do not attain the acceptable level have difficulty with fundamental concepts such as oxidation and reduction and in using data tables to extract appropriate information.

In **numerical-response question 2**, 80.7% of students could identify four reducing agents from experimental data. Virtually all students (97.5%) who attained the level of excellence and 80.3% of the students who attained the acceptable standard were successful. Only 46.6% of the students who did not attain the acceptable standard were able to do this. The most common mistake students made (11.4%). was in believing that reducing agents undergo reduction. When students are asked to rank-order oxidizing or reducing agents based upon strength from the experimental data, as in **numerical-response question 3**, 87.0% of the students who attained the standard of excellence were capable of ranking the oxidizing agents. Of students attaining the acceptable standard, 63.8% had some difficulty, while only 29.5% of students who did not attain the acceptable standard were successful. This suggests that students achieving the acceptable level do so because they are capable of applying more than one skill or concept to a problem to arrive at an answer.

Students just attaining the standard of excellence were capable of answering questions such as multiple-choice question 30 and numerical-response questions 4, 8, 10, and 11. For example, in **numerical-response question 10**, students attaining the standard of excellence were able to select the K_a expression (74.7%) and then solve for pH (71.0%). Of the students who attained the acceptable standard, 47.9% could identify the K_a expression and only 19.8% could correctly determine the pH. Very few of those who did not attain the acceptable standard were able to select the K_a expression (27.8%), and only 1.8% could then solve for pH. The most common mistake was in not

Use the following information to answer the next question.



30. A 25.0 mL sample of citric acid is titrated to the **final** equivalence-point with 0.100 mol/L sodium hydroxide solution in the presence of a phenolphthalein indicator. Which of the following statements is correct?

A. The end-point is reached when the concentration of the acid equals the concentration of the base.

***B.** The end-point is reached when the concentration of $HPh_{(aq)}$ approximately equals the concentration of $Ph_{(aq)}^-$.

C. The equivalence-point is reached when the volume of base equals the volume of acid.

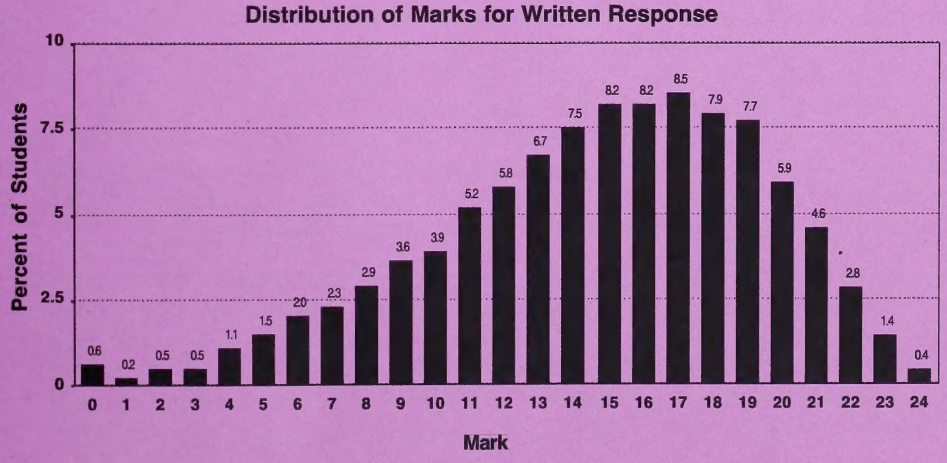
D. The equivalence-point is reached when the pH is equal to 7.00.

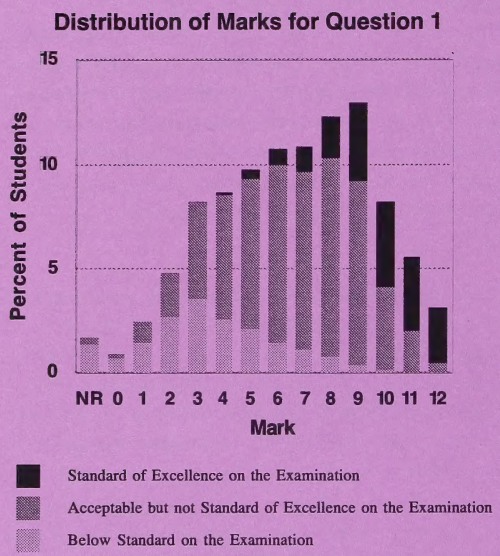
recognizing that hypochlorous acid is a weak acid and hence does not dissociate completely. The 43.0% of students who made this error did not use the K_a expression and calculated a pH of 1.70. The results for this question suggest that students attaining the standard of excellence do so because they are capable of distinguishing between strong and weak acids, recognizing when an equilibrium exists, selecting the appropriate K_a expressions, and then mathematically solving the problem using valid stoichiometry.

In **multiple-choice question 30,** as expected, most students (71.1%) could not distinguish between the concept of a reaction's equivalence point and an acid-base indicator's end-point. As a result, only 28.9% of all students were successful in answering this question correctly. The most common mistake, made by 39.2% of students, was to confuse concentration of a solution or the volume of a solution (12.6%) did so with the moles of reagent present in a 25.0 mL sample. A misconception students had was in assuming that the equivalence point of all reactions occurs when the pH of the mixture is equal to 7 (19.2%), even though the titration plot clearly indicates that this is not true. Of students who attained the standard of excellence, 50.5% were successful in answering this question, compared with 25.6% of students who attained the acceptable standard and of 16.9% of students who were incapable of attaining the acceptable standard. This result suggests that students who attain the standard of excellence do so because they are able to integrate several concepts and use graphical data to answer a question.

Written-Response Questions

The level of achievement on the written-response section was as expected: three quarters of the students (75.7%) achieved a mark of 12 or higher out of 24. The average mark on the written-response section was 14.6 or 60.8% of the available marks.




Distribution of Marks for Question 1
Percent of Students
15
10
5
0
NR 0 1 2 3 4 5 6 7 8 9 10 11 12
Mark
Standard of Excellence on the Examination
Acceptable but not Standard of Excellence on the Examination
Below Standard on the Examination

Written-response question 1 was answered as well as expected. The question was selected to measure students' ability to apply their understanding of acid-base chemistry. Students were required use their knowledge to describe any two methods that could be used to distinguish between a strong acid and a weak acid. There was a vast range of valid methods presented by the students. Many methods were both correct and novel. All answers were judged on their own merit, and if they were adequately explained, were awarded full marks. Students who did not attain the acceptable standard were expected to score between 0 to 5 and 78.8% did so. They averaged 3.61 by relating pH of the sample to the strength of the solution. However, their selection of methods indicated that they had difficulty in distinguishing between strength and concentration even though the question indicated that the solutions were of equivalent strength. They were generally successful in selecting one method, usually the pH "test," that would work, but they had difficulty in explaining how the method identified the acid as being either weak or strong. Most of the responses where students used indicators as the method of determining pH contained flaws. The most common were the beliefs that only one indicator should be used or that the colour of litmus varied directly with the strength of acid (the stronger the acid, the redder the litmus paper). However, students did demonstrate a knowledge of acidic properties and definitions of acids, and, as a result, some students suggested tasting, dipping of clothing, and immersion of fingers as suitable methods to determine the nature of the acid. Unfortunately, some of the students who did not attain the acceptable standard misinterpreted the question entirely and gave methods based upon distinguishing between acids and bases. Most of these students' responses were very ambiguous, poorly organized, and weakly communicated. Spelling and grammatical errors were the norm.

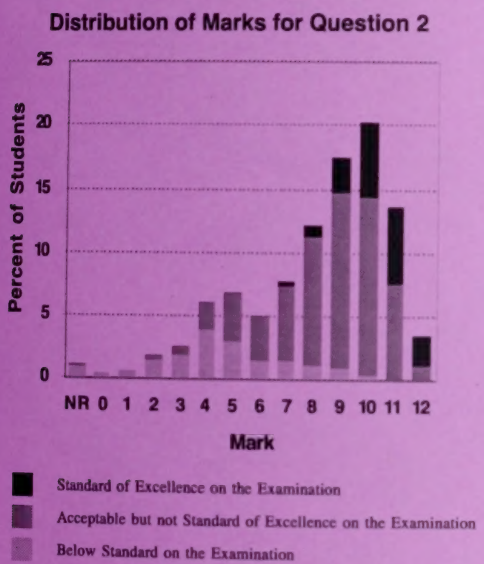
Students who attained the acceptable standard but not the standard of excellence on the examination were expected to score in the range of 6 to 9 and 55.9% did so. They averaged 6.51 by usually describing two valid methods. Generally, they covered one method very well but had difficulty with a second method. When the method involved the use of indicators, students rarely used more than one indicator to establish a range of pH values to identify the nature of the acid. If they selected more than one indicator, they had difficulty in explaining how the group of indicators would have to be used to identify the strength of the acid. Many of these students correctly used conductivity of the solution as one of their methods. They also described how a pH meter may be used to determine the pH of the sample. Another commonly selected method was titration of the samples and estimation of the strength of the solution based upon the volume of the titrant used. Even though this method could work, most of these students had difficulty in putting it together. The most common mistake was the titrating of the sample to its equivalence point of the "reaction end-point" rather than to a predetermined pH such as 7. Clearly these students believed that stronger acids require more base to neutralize them since they contain more hydronium ions. This reveals a confusion between total hydrogen ion available for transfer (concentration) and amount of disassociated solute (strength). This group of students appeared desperate to do calculations, and as a result, many papers contained calculations that did not aid in the solution. Most of these students' responses were lengthy and lacked organization.

Students who attained the standard of excellence were expected to score 10 or better, and 56.2% did so. They averaged 9.56 by clearly communicating their answers and by selecting two valid methods by which the strength of an acid could be determined. Virtually all of these students focused on the fact that strong acids completely disassociate while weak acids do not. They also keyed in on the fact that the majority of weak acids, when reacted with a strong base, have an equivalence-point at a pH greater than 7. Another approach these students took was to assign a value to the concentration of the solution and select representative examples of strong and weak acids to show how their results

would be compared to reveal the identity of two samples of acids. Some of these students used diagrams and graphs to illustrate their answers. The most common approach these students took was to use the conductivity and the pH of the solution, as measured by either a series of indicators or a pH meter, to establish the nature of the acid. Most students realized that since the actual concentration was not specified, their method should be capable of measuring pH values over a wide range. Overall, these students selected simple methods to accurately answer the question. This approach clearly demonstrates that they understand the concept and, in general, are not drawn into complicated methods to solve straightforward issues. Regardless of the methods selected, these students showed good communication and organizational skills.

The results on this question suggest that most students attaining the acceptable standard are capable of selecting methods capable of generating data to identify the strength of an acid and can give simple explanations of how these methods worked. The students who attain the standard of excellence recognize that many methods do solve the problem and can back up their selection with elaborate and accurate justification.

On this 12-mark question, the average mark was 6.55 or 54.6% of the available mark.



Written-response question 2 was answered better than expected by the student at or close to the acceptable standard. The question was selected to measure students' ability to perform stoichiometric operations and to demonstrate their knowledge of significant digits. The question was also intended to give students an opportunity to demonstrate a responsible judgement given a situation and some background information. Students who did not meet the acceptable standard were expected to score up to 5, and 67.7% met this expectation. They averaged 4.63 because they were able to write an unbalanced chemical equation for the combustion of butane. Unfortunately, they were unable to determine the molar heat of reaction since a large number of these students believed that "$mc\Delta t$" must be used. For those students who recognized that Hess's Law was involved, most could indicate the method required but were unable to successfully complete the calculation. They had great difficulty in determining the correct number of significant digits and usually omitted or ignored units. When these students were asked to take a position on the continued use of butane as a propellant, they usually made statements about both the butane and the CFCs, but did not take a position, as required by the question. As a result, markers had to interpret their responses, which, in many cases, contained numerous errors of convention. The students also were confused as to the source of greenhouse gases as it related to the question. Some students went to great lengths to explain how the carbon dioxide formed in the combustion could lead to acid rain and increased global temperatures, even though butane, when used as a propellant, does not form carbon dioxide. These students did receive marks for justifying issues raised in their response.

Students who attained the acceptable standard but not the standard of excellence were expected to score up to 9 and scored, on average, 8.45. In total, 64.0% of these students met this expectation. They correctly wrote a balanced chemical equation for the combustion of butane, knew Hess's Law, and were able to substitute valid values to determine a correct answer. The only problem students had in part a lay in the consistent use of units and significant digits. In part b, they selected a position and provided a reason for their selection. Most responsibly chose to retain butane as a propellant rather than using CFCs, but they had difficulty in justifying their reasoning and were confused about what a greenhouse gas was. Their responses tended to be dramatic, lack organization, ramble, and change path in mid-sentence, which resulted in markers having to interpret their responses.

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Students who attained the standard of excellence were expected to score 10 or better and averaged 10.24 for this question, with only 12.5% attaining a perfect score. They were able to calculate a correct molar heat of reaction for the combustion of butane. They had no difficulty in selecting a position and providing sound reasoning and justification for it. They chose to retain butane as a propellant rather than CFCs, and they justified this by either electing to elaborate on the problems with a CFC alternative or to point out the benefits of retaining butane. They recognized that unfortunate, and sometimes tragic, incidents occur, but balanced individual against global concerns. Some of these students successfully proposed valid alternatives to either butane or the CFCs. The only area of weakness lay in careless errors involving significant digits and units in the calculations. These students presented their answers in a concise, organized fashion and expressed themselves clearly to the markers so that little, if any, interpretation was required.

Students attaining the standard of excellence do so because they can analyze a situation and make an informed value judgement that recognizes that a freak accident, although unfortunate, is no reason to select alternatives that pose a greater hazard to the human environment.

On this 12-mark question, the average mark was 8.08 or 67.3% of the available mark.

For further information, contact Don Loerke (DLoerke@edc.gov.ab.ca) or Yvonne Johnson at the Student Evaluation Branch, 1-403-427-0010.

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